Hydrogeology of Shallow Groundwater Resources
Geneva-Batavia Township, Kane County, Illinois

Timothy H. Larson
Stephen S. McFadden
Robert H. Gilkeson

Open File Series 1992-5

ILLINOIS STATE GEOLOGICAL SURVEY
Morris W. Leighton, Chief

Natural Resources Building
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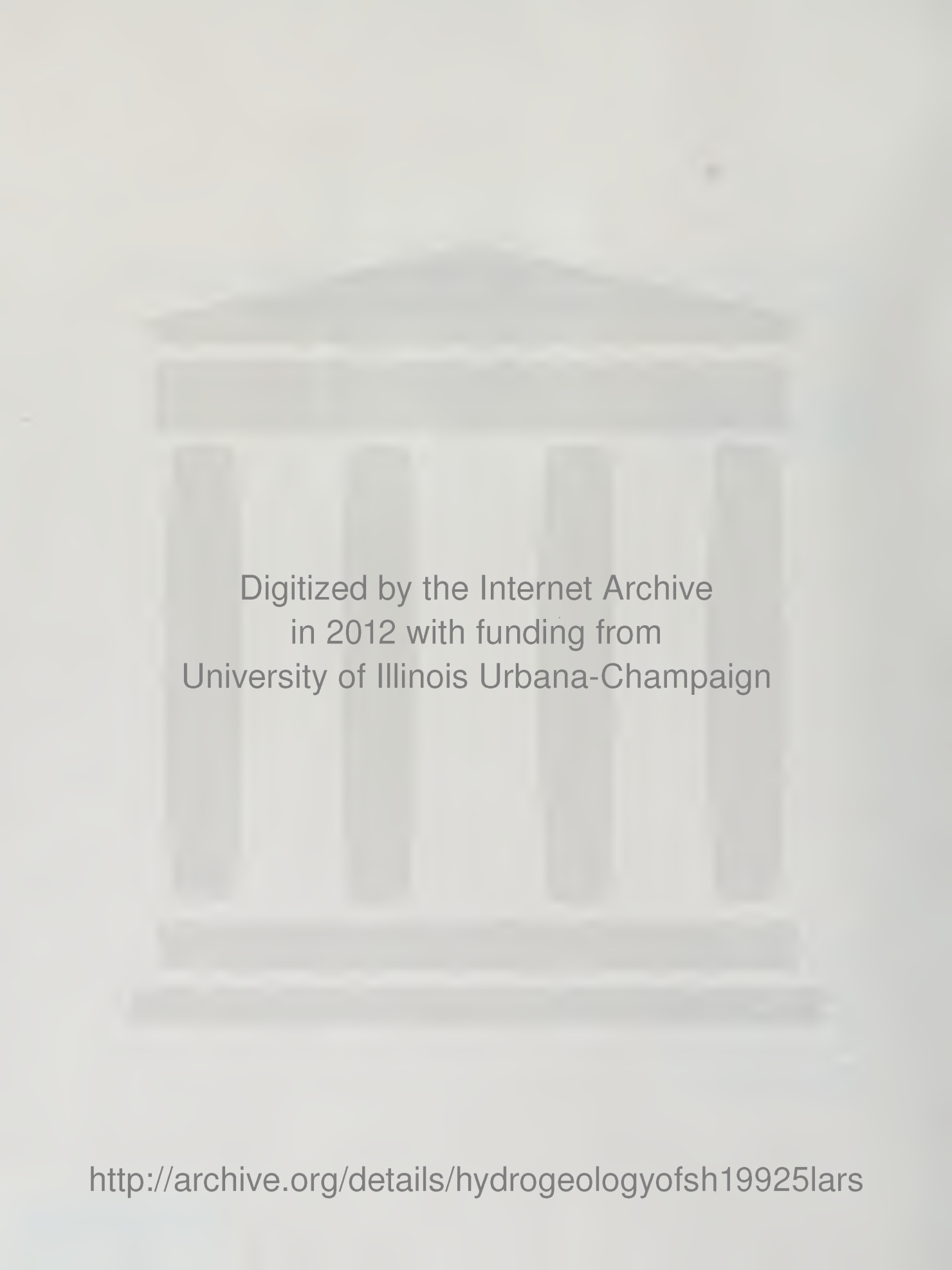

CONTENTS

TABLE

FIGURES

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ABSTRACT

The St. Charles aquifer, a highly productive sand and gravel aquifer, occurs about 100 to 150 feet deep in the buried St. Charles bedrock valley in the western part of the study area. This aquifer is greater in thickness and areal extent west of Geneva than it is farther south, where it lies west of Batavia. A shallow sand and gravel aquifer, the Kaneville aquifer member of the Elburn aquiformation, is present above the St. Charles bedrock valley and in the northern and eastern parts of the study area.

Declining water levels and high concentrations of radium and chloride in the present source of water, the deep (400 to 2,000 ft) sandstone aquifers of the Basal and Midwest Aquigroup, have made it necessary for the cities of Geneva and Batavia to explore alternative water sources. To support their investigation, the Illinois State Geological Survey has mapped the shallow aquifers of the area using a combination of existing records, surficial geophysical surveys, and test-hole drilling. Maps prepared for this report can be used to explore further and test other areas for aquifer interconnection.

INTRODUCTION

Sandstone aquifers of the Basal Bedrock and Midwest Bedrock Aquigroups of northeastern Illinois have supplied much of the public water for northeastern Illinois. The cities of Geneva and Batavia in Kane County (fig. 1) have relied almost exclusively on these water sources. However, declining water levels caused by overpumping (Sasman et al. 1982) and high

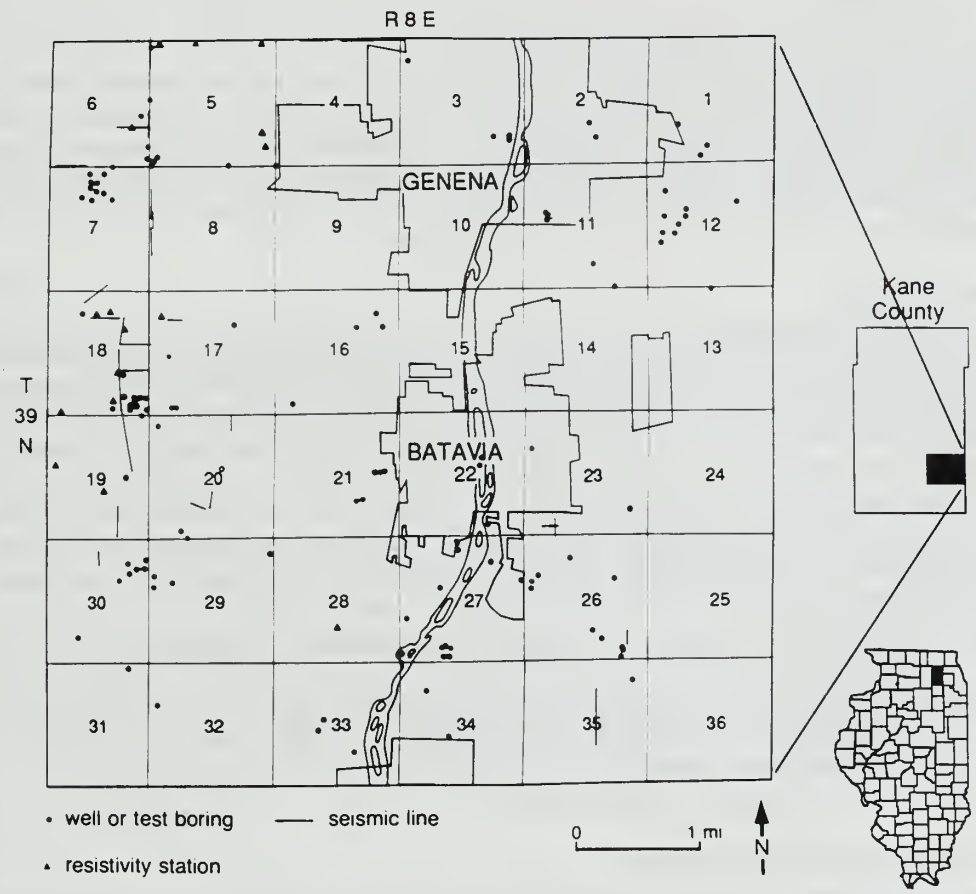

Figure 1 Location of the study area in Kane County. Symbols show locations of wells, seismic lines, and resistivity stations used as data in this report.

concentrations of naturally occurring radium and chlorides (Gilkeson et al. 1984) have made it advisable for the cities to evaluate alternative water sources. Other possible sources of water include sand and gravel aquifers in the glacial sediments (Prairie Aquigroup), aquifers in the shallow fractured bedrock (Upper Bedrock Aquigroup), and the Fox River.

This study identified the shallow groundwater resources (Prairie Aquigroup and Upper Bedrock Aquigroup) in Geneva-Batavia Township. The Illinois State Geological Survey (ISGS) used existing well records, surficial geophysical methods, and test drilling to map the shallow groundwater aquifers in the study area. The Illinois State Water Survey, in a separate investigation, is evaluating the hydraulic properties of the shallow aquifers. Aquifer pump tests will determine well yield, well spacing, potential aquifer yield, and shallow groundwater chemistry.

Two other studies in Kane County provided additional information on the shallow groundwater hydrology of the study area. A major study funded by Kane County and several communities produced a regional perspective of the shallow groundwater resources in the vicinity of the study area. Much of the technical background provided in the final report for the Kane County project (Curry and Seaber 1990) is pertinent to Geneva-Batavia Township and thus is referenced in this report. Kane County was also part of an extensive geotechnical study for siting the proposed Superconducting Super Collider (SSC). Graese et al. (1988) summarized the SSC-related investigations.

METHODOLOGY

Well records, test borings, surficial geophysical surveys, and existing reports and maps provided information on the glacial drift, drift thickness, bedrock surface and lithology, aquifer properties, and groundwater quality. Sources of data, in addition to existing well records and test wells drilled for this project, included the regional Kane County project and the SSC siting project. The maps and general conclusions of this report are derived from Graese et al. (1988) and Curry and Seaber (1990). We have included specific information relevant to Geneva-Batavia Township and revised the maps accordingly.

Well Records

Well records on file at the Illinois State Geological and Water Surveys were used in the study. (Well locations are shown on fig. 1.) Well logs, recorded at the time of drilling, document the locations of wells and the geologic materials encountered during drilling. Well records were from privately drilled wells, municipal and industrial wells, and test wells. Commonly, well locations described in the logs from private wells are inaccurate or very general. Private well locations were verified at the Kane County Permit Office. In most cases, descriptions of glacial drift lithology in drillers' logs of private wells were poor to adequate, but data on the depth to bedrock were considered reliable. Records of wells with unverified locations provided general information on geologic trends in areas of sparse data coverage. Records of public supply wells for the municipalities in Kane County provided detailed and reliable data on the lithologic units.

Published sources of well records in Kane County include Lund (1965), Reed (1975), Woller and Sanderson (1978), Kempton et al. (1985, 1987a, 1987b), Curry et al. (1988), and Vaiden et al. (1988). These records provided information on bedrock depth and lithology, and on the thickness and lithology of the glacial drift.

Surficial Geophysical Surveys

Seismic refraction, a surficial geophysical method, was used for detailed mapping of the bedrock topography and glacial drift thickness. (Locations of seismic surveys are shown on fig. 1). In this procedure, seismic energy traveling through the ground is refracted back to ground

surface from the interface between the glacial sediments and the bedrock. A buried explosive charge or weight-drop system serves as an energy source to produce seismic waves.

Reversed profile seismic data were gathered using a 24-channel signal-enhancement seismograph. Geophones were spaced 50 fet apart along lines 650 feet long, or 100 feet apart along lines 1,300 foot long, depending on the thickness of the glacial drift and seismic velocities of the geologic materials. Field data were automatically processed with a modified version of a ray-tracing program (SIPT-1) written by the U.S. Bureau of Mines (Scott et al. 1972). The SIPT-1 program corrects for irregular surface terrain along the seismic profile and also calculates the depth to bedrock beneath each geophone.

Anomalously great depths to bedrock are calculated by means of the seismic refraction method in areas where thick sand and gravel deposits are overlain by thick, clay-rich glacial till (Zohdy et al. 1974). The anomalies occur because the sand and gravel layer has a lower seismic velocity than both the overlying till and underlying bedrock. The error in calculated depth is proportional to the thickness of the sand layer and always results in greater calculated depths to bedrock than actually exist. Because the anomalies are caused by buried sand and gravel, they are potential targets for further groundwater resource evaluation.

A second surficial geophysical method, electrical earth resistivity, was used as a qualitative tool to determine the texture of the geologic materials present in the glacial drift (fig. 1). A Schlumberger electrode configuration was used (Zohdy et al. 1974), and the data were inverted to layering parameters (Zohdy 1973). In freshwater environments, sand and gravel units have a higher resistivity than finer grained glacial till and can be easily identified by this method. Identification is difficult, however, where the sand and gravel deposits are thin, deeply buried, or in contact with carbonate bedrock (McGinnis and Kempton 1961). Thickness determinations are not possible where the bedrock and overlying glacial drift have similar resistivities, such as a coarse sand and gravel overlying dolomite. Therefore, electrical earth resistivity data were primarily used in conjunction with seismic refraction to identify sand and gravel deposits within the glacial drift.

Test Drilling

Test holes for new public supply sources were drilled in areas identified as favorable by the geophysical surveys conducted as part of this and related local studies. Test holes were geophysically logged with a natural gamma-ray probe to identify aquifer materials and to assist in making stratigraphic correlations. Test drilling also provided the specific information required for the design of an aquifer test and production well.

Results from an aquifer test for Geneva, along with results from tests in Aurora and Montgomery (south of the study area), were presented by Gilkeson et al. (1987). These and other tests were summarized in an appendix by Curry and Seaber (1990).

Test drilling in Kane County was conducted for siting of the proposed SSC. Continuous cores of the bedrock sequence and discontinuous cores of glacial drift were collected; suites of geophysical logs were run. Results of this drilling program were reported in Kempton et al. (1987a, 1987b), Curry et al. (1988), and Vaiden et al. (1988).

GEOLOGIC FRAMEWORK

Stratigraphy

The geology of the area includes Precambrian crystalline basement rocks, Paleozoic sedimentary rocks, and Quaternary uncemented sediments. In northern Illinois, the Paleozoic history from 600 million to 245 million years ago is represented by rocks that have a marine

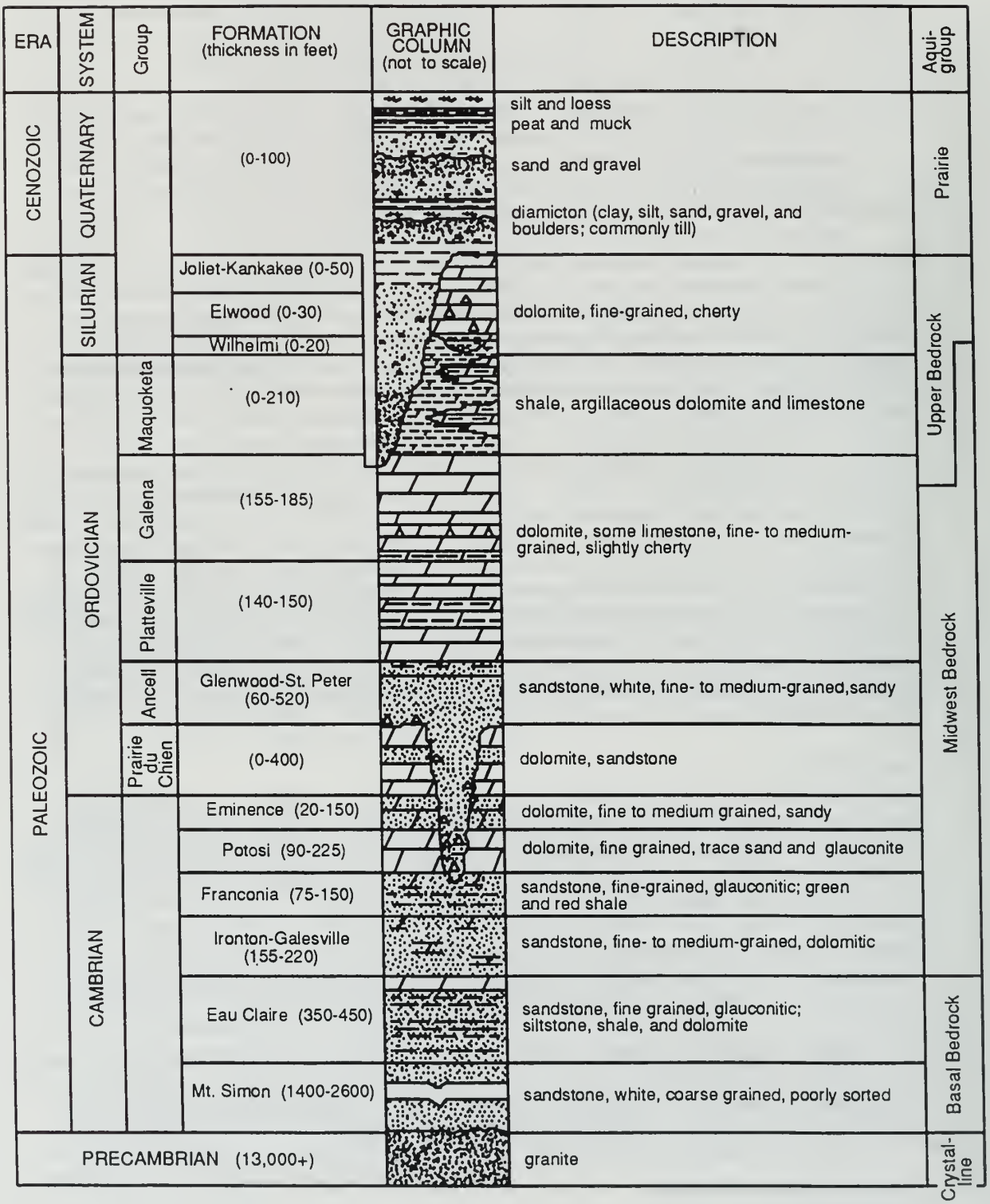

Figure 2 Stratigraphy of rocks underlying Geneva-Batavia Township.

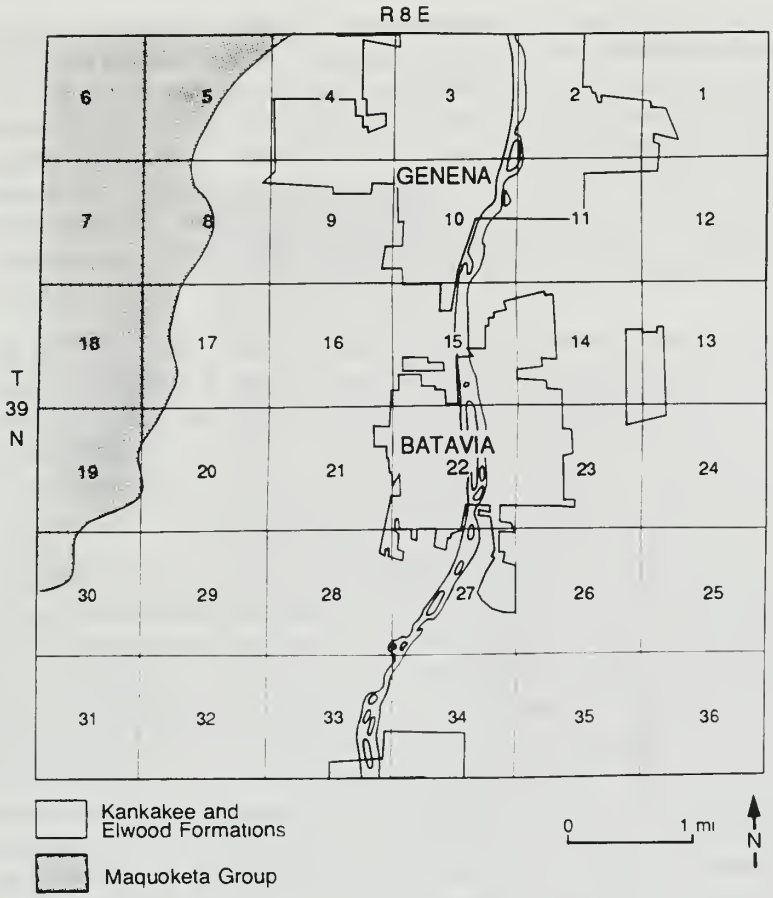

Figure 3 Areal geology of the bedrock surface.

origin (fig. 2) and a maximum thickness of 4,000 feet (Kempton et al. 1985). The Paleozoic rocks are overlain by Quaternary sediments as much 100 feet thick.

Bedrock The Paleozoic rocks most significant to the shallow groundwater resources in the area are the Ordovician Maquoketa Group and the Silurian Kankakee and Elwood Formations (Willman et al., 1975) (fig. 3). (The deeper aquifers in the area are beyond the scope of this study, but are discussed in Visocky et al. [1985].) The Maquoketa Group is composed of shale, argillaceous dolomite and limestone, and interbeds of shale and dolomite; it is present at the bedrock surface in buried bedrock valleys beneath Geneva-Batavia Township. The regionally important formations of the Maquoketa include, in ascending order, the Scales Shale, Ft. Atkinson Limestone, Brainard Formation, and Neda Formation (Kolata and Graese 1983); but these cannot be readily differentiated in Kane County (Graese et al. 1988). Here, the Maquoketa consists of two sequences composed of basal shales that become increasingly carbonate rich. In Geneva-Batavia Township, the shale is more dominant in the western portions, where the Maquoketa is present at the bedrock surface; however, carbonate-rich rocks become more dominant in the upper Maquoketa in the eastern portion of the township.

The Elwood and Kankakee Formations are composed of thin to medium-thick beds of dolomite; the Kankakee also contains abundant nodules and interbeds of chert. Because the lithology of these units is similar, they are not differentiated in this report. The distribution of the Kankakee and Elwood Formations at the bedrock surface (fig. 3) is determined chiefly by the buried bedrock topography. The total thickness of dolomite, including portions of the Maquoketa Group, approaches 150 feet on the east side of Batavia.

Quaternary deposits Local stratigraphic classification of Quaternary deposits is illustrated on figure 4a; the sediments consist of glacial till, glacial outwash, glacial lakebed materials, eolian (windblown) sediments, and recent deposits along steep slopes and floodplains (Curry and Seaber 1990). Distribution of the surficial drift units is shown on figure 4b. These deposits were produced in a variety of depositional environments associated with major glacial advances and retreats between approximately 1.6 million to 14,000 years ago. Successive glacial advances modified the sediments deposited by earlier events and further complicated the geometry of the various units. Finally, since the retreat of the most recent glaciers, glacial deposits have been modified by erosion, predominantly in fluvial environments such as the present Fox River valley.

The oldest glacial drift identified in Kane County is Illinoian and may correlate to the Glasford Formation near Rockford in Boone and Winnebago Counties (Berg et al. 1985). Illinoian deposits are covered by Sangamonian and early to middle Wisconsinan colluvium composed of organic carbon-rich, silty deposits that have been modified by soil formation; these include Berry Clay and Robein Silt (fig. 4). These sediments may be as much as 25 feet thick in Kane County; but more commonly, they are thin or absent (Curry and Seaber 1990).

The late Wisconsinan Wedron Formation, Henry Formation, and related formations (Willman and Frye 1970) cover the Robein Silt. The bulk of the late Wisconsinan deposits belong to the Wedron Formation; its representative members in Kane County are, in ascending order, the Tiskilwa, Malden, Yorkville, and Haegar Till Members (figs. 4a and b). Till members consist of diamicton (poorly sorted sediment deposited directly or indirectly by glacial ice) interlayered with outwash (well sorted sand and gravel deposited by glacial meltwater). The Yorkville Till Member is the predominant surficial deposit in Geneva-Batavia Township; the Malden is present at the surface in the extreme western portions of the township; the Tiskilwa is commonly present in the subsurface; however, the Haeger is not present in the township. The Henry Formation consists of sand and gravel; its distribution and thickness are relatively well known because of its importance as an aggregate resource (Masters 1978). The Equality Formation is composed of stratified to massive sand, silt, and clay associated with sedimentation in lakes; it is a common surficial deposit across Kane County (Graese et al. 1988), including portions of Geneva-Batavia Township. Generally, it is less than 20 feet thick, but it may be as much as 45 feet thick (Curry and Seaber 1990). Richland Loess mantles the upland landscape, but it is generally less than 2 feet thick and has not been mapped for this report.

Holocene sediments, deposited since the last glaciers melted away, are thin and occur along drainage ways (Cahokia Alluvium) and in shallow or drained wetlands (Grayslake Peat, fig. 4b).

Bedrock Surface Topography

The bedrock topography of the state was mapped by Horberg (1950). More recently, bedrock topography maps have been published for all or part of Kane County by Graese et al. (1988) and Curry and Seaber (1990). For this report, the bedrock surface map of Geneva-Batavia Township (fig. 5) was prepared from existing data and supplemented with detail from seismic refraction and test drilling. This map was modified from the map provided by Curry and Seaber (1990).

The bedrock surface is characterized by bedrock uplands dissected by valleys that trend generally northeast-southwest or northwest-southeast. The buried bedrock surface typically does not follow the present-day topography, which is related to Pleistocene glaciation. The bedrock valleys represent a previous drainage system that developed before glaciation. These ancient valleys were extensively modified and eventually buried by processes related to glacial activity. Elevation of the bedrock surface in the study area varies from less than 500 feet above mean sea level (msl) west of Batavia to more than 700 feet msl east of Geneva.

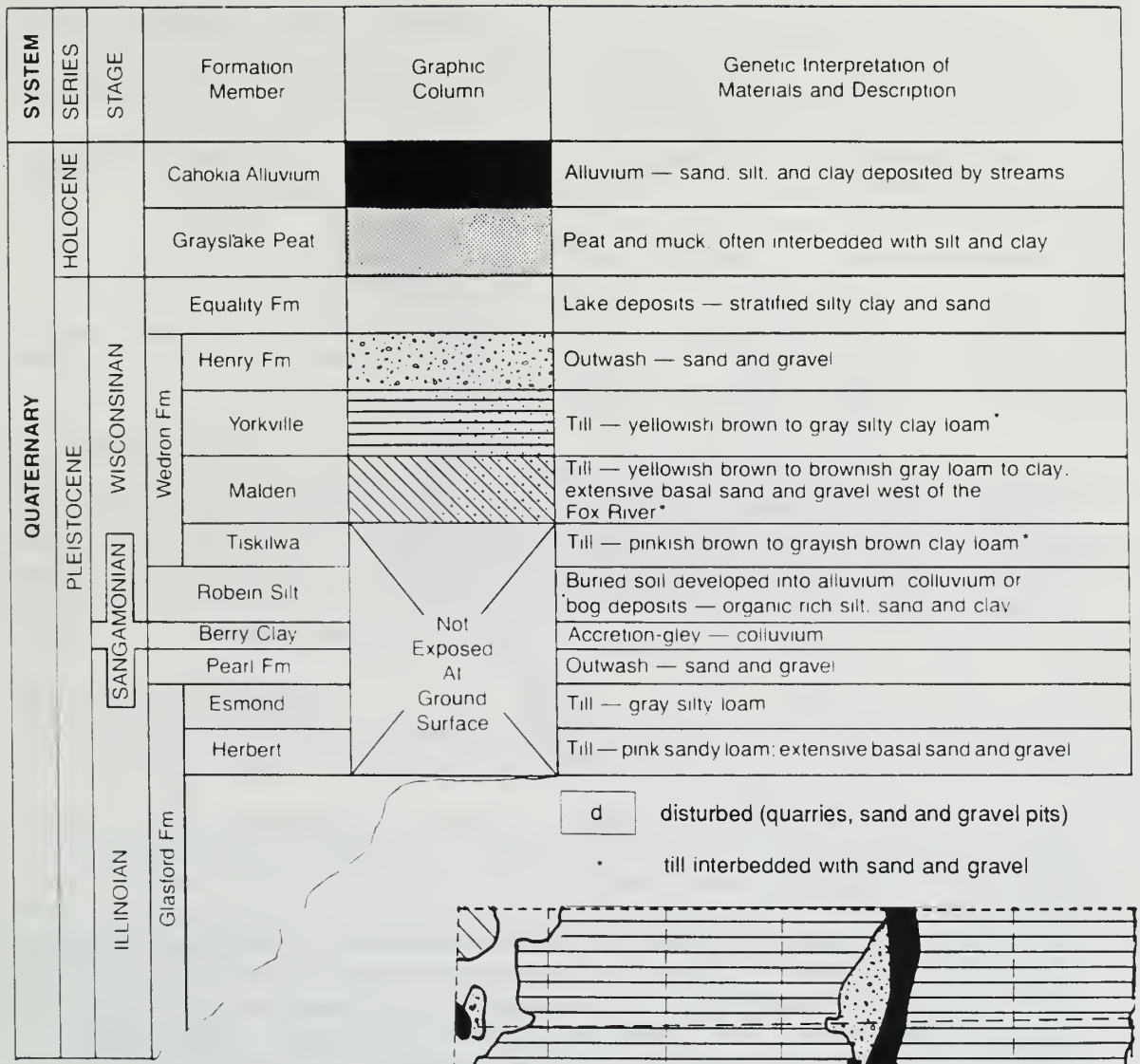

Figure 4a *(above)* Stratigraphy of glacial drift (Prairie Aquigroup) underlying Geneva-Batavia Township. Not all units are present within the study area.

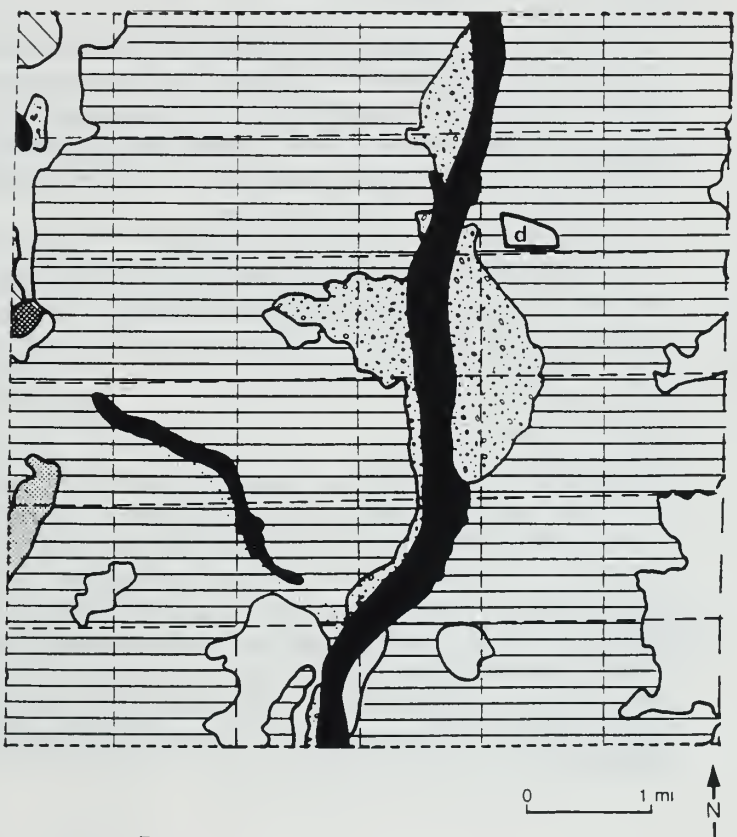

Figure 4b *(right)* Surficial drift map of Geneva-Batavia Township.

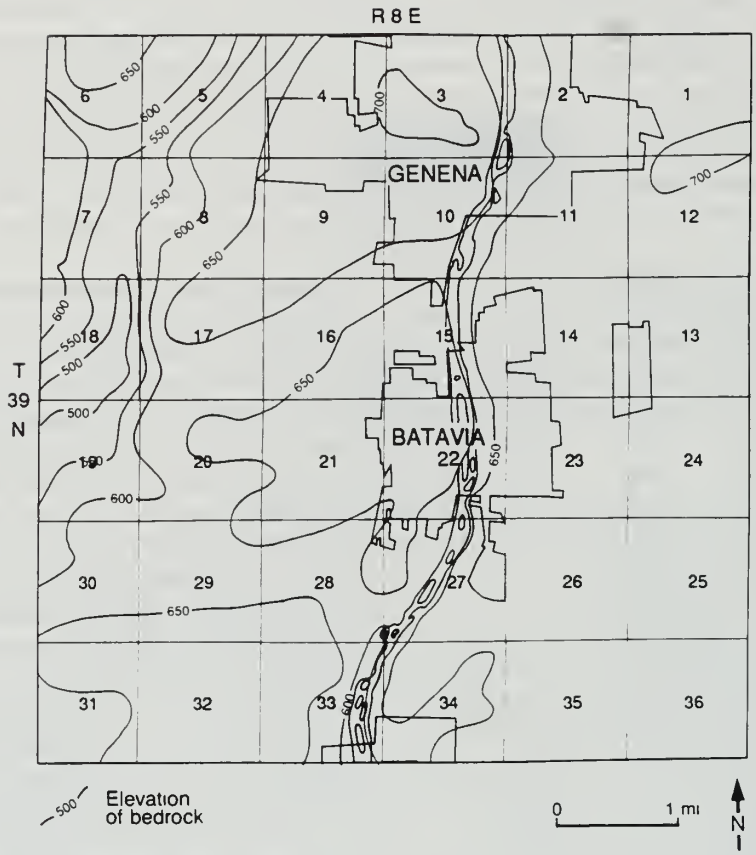

Figure 5 Elevation of the bedrock surface.

The St. Charles bedrock valley (called the Newark Bedrock Valley in some previous reports) is the major bedrock drainage feature of the study area and throughout Kane County (Curry and Seaber 1990). The valley, trending south-southwest, cuts across the northwest corner of Geneva-Batavia Township. The eastern wall of the St. Charles bedrock valley is steep, especially west of Batavia where bedrock elevation decreases 175 feet in less than 1/2 mile. The western wall slopes more gently.

The area to the east of Geneva and Batavia is characterized by a relatively high, featureless bedrock surface ranging in elevation from 675 to 700 feet msl. The Fox River is incised into the bedrock. Some erosion of the bedrock surface in the Fox River Valley is probably related to glacial activity.

Drift Thickness

Variations in the thickness of glacial drift (sediments) are the result of bedrock topography, glacial landforms such as moraines, and erosion in postglacial environments. The glacial drift is up to 200 feet thick in the St. Charles bedrock valley where it underlies the study area. Glacial moraines, the ridges of thick drift deposited directly from glaciers, may not be associated with bedrock topography. Moraines were formed at locations where ice margins remained relatively stable over long periods of time. An example of this relationship occurs east of Geneva and Batavia, where drift thickness varies from 50 to 100 feet. The third factor controlling drift thickness is illustrated along the Fox River. Erosion of glacial materials probably occurred when the Fox River Valley was forming and resulted in relatively thin drift and locally exposed bedrock along the course of the river.

Table 1 Informal classifications of drift aquifers in Kane County

McFadden et al. (1989)	Schicht et al. (1976)	Graese et al. (1988)	Curry and Seaber (1990) and this report
			Prairie Aquigroup
Upper sand and gravel aquifer	Surficial sand and gravel aquifer	Surficial drift aquifer	Valparaiso aquifer Kaneville aquifer of Elburn aquiformation
	Interbedded sand and gravel aquifer	Basal drift aquifer	Bloomington aquifer
Lower sand and gravel aquifer	Basal sand and gravel aquifer	Buried drift aquifer	St. Charles aquifer

HYDROGEOLOGY

Major hydrostratigraphic units were formally defined for the area by Visocky, et al. (1985). The Prairie and Upper Bedrock Aquigroups provide the shallow groundwater resources for Kane County. For consistency, we have adopted the informal names defined for local or regional drift aquifers (Prairie Aquigroup) in Kane County by Curry and Seaber (1990). Many older reports use different names for the same aquifers. Table 1 provides a comparison between aquifer names used in this report and previous usage.

Upper Bedrock Aquigroup

The Upper Bedrock Aquigroup consists of local and intermediate flow systems in sedimentary rocks that directly underlie and interconnect with the glacial sediments of the Prairie Aquigroup.

In Kane County, the Upper Bedrcok Aquigroup consists of the Ordovician Maquoketa Group and Silurian Elwood and Kankakee Formations. The dolomites of the Silurian Elwood and Kankakee Formations are the most significant and productive. The dolomite aquifer or shallow dolomite aquifer (figs. 2 and 3), as it is informally known, sustains pumping rates as great as 100 to 200 gallons per minute (gpm) (Visocky et al. 1985). Within the study area, the Silurian rocks thin westward and are replaced at the bedrock surface by rocks of the Maquoketa Group. Where the Maquoketa Group is dominated by shale, the Upper Bedrock Aquigroup becomes much less productive. The hydrogeology and yields of these units are discussed in Csallany and Walton (1963). Packer test data for these units are summarized in Curry et al. (1988).

Table 2 Informal hydrostratigraphic hierarchy in Kane County (modified from Curry and Seaber 1990)

Aquigroup	Aquiformation	Aquimember
Prairie	Valparaiso aquifer Elburn aquiformation Bloomington aquifer Pingree Grove aquiformation Marengo aquitard St. Charles aquifer	Kaneville aquifer member

Prairie Aquigroup

In Kane County, the Prairie Aquigroup has local and intermediate flow systems in noncemented geologic materials, including glacial drift, alluvium, and other recent sediments. The aquifers are confined locally by fine-grained sediments. Recharge to the system is mainly from local precipitation. Of the six hydrostratigraphic units that Curry and Seaber (1990) informally recognized in Kane County (table 2), four are important in Geneva-Batavia Township. These

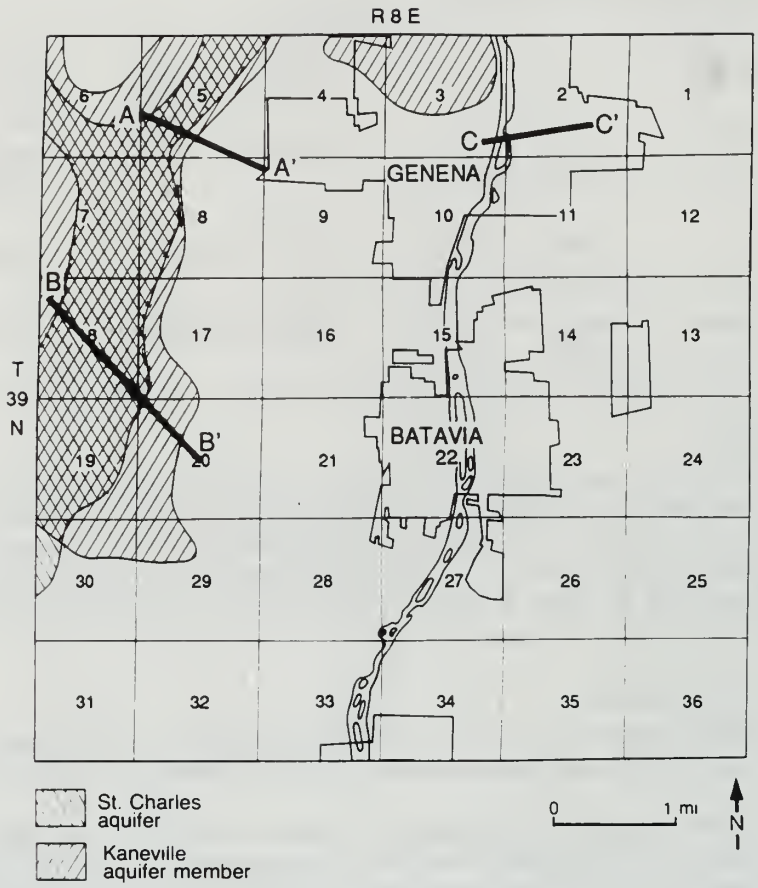

Figure 6 Major aquifers of the Prairie Aquigroup within Geneva-Batavia Township. Figures 7a-b and figure 8 show the three-dimensional relationships indicated on cross sections A-A′, B-B′, and C-C′.

are the St. Charles aquifer, the Marengo aquitard, the Kaneville aquifer member of the Elburn aquiformation, and the Pingree Grove aquiformation.

St. Charles aquifer Composed chiefly of sand and gravel of the Wedron and Glasford Formations, the St. Charles aquifer occurs primarily within the buried St. Charles bedrock valley. It exceeds 100 feet in thickness west of Geneva.

The distribution of the St. Charles aquifer, where it exceeds 50 feet in thickness, is shown on figure 6. In this township, the aquifer consists of proglacial outwash of the Tiskilwa Till Member of the Wedron Formation. Because of the complex relationship between till and outwash, the boundary of the sand and gravel within the St. Charles aquifer, as shown on figure 6, is only approximate.

The St. Charles aquifer is shown vertically in relation to other Prairie Aquigroup members on figures 7a-b. These cross sections are oriented east-west across the St. Charles bedrock valley in the western part of the study area. (Locations are shown in figure 6.) The steep eastern and more gently sloping western walls of the bedrock valley are evident in cross section figure 7b.

Marengo aquitard The Marengo aquitard covers the St. Charles aquifer in much of the study area (figs. 7a-b). The aquitard is chiefly made up of diamicton (till) of the Tiskilwa Till Member of the Wedron Formation (Wickham et al. 1988).

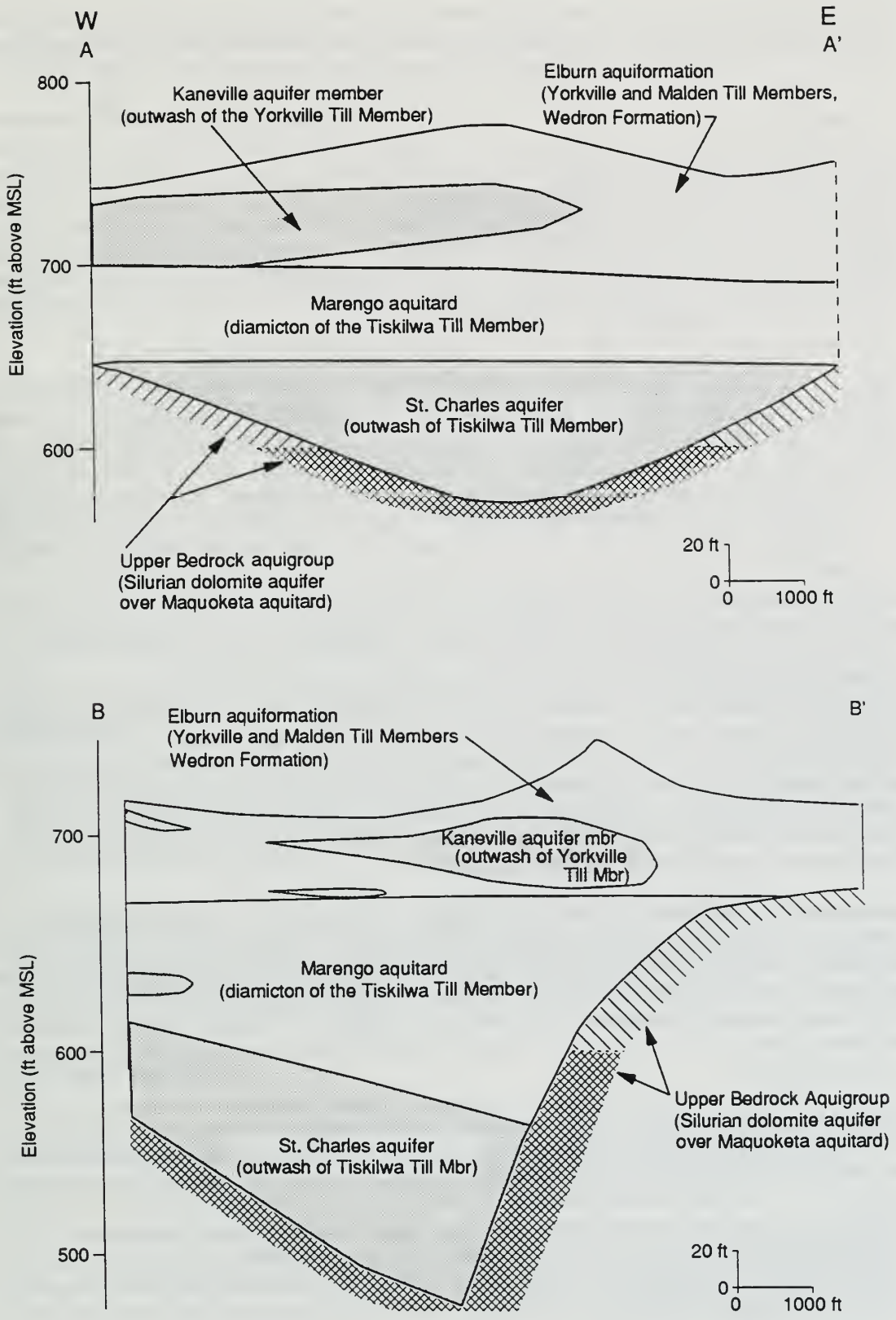

Figure 7 Cross sections of the St. Charles bedrock valley: *a (bove)* west of Geneva; *b (below)* west of Batavia.

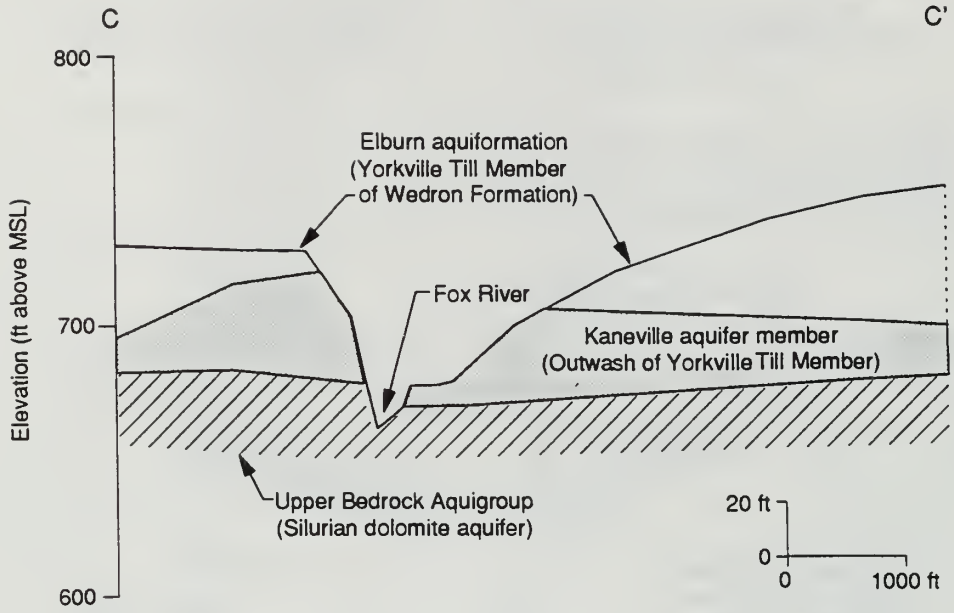

Figure 8 East-west cross section near Geneva showing relationships of the Elburn aquiformation.

The Marengo aquitard has a field-measured hydraulic conductivity on the order of 0.2 to 0.002 gal/day/ft^2 (10^{-6} to 10^{-8} cm/sec) (Jennings 1987). Materials with such low hydraulic conductivities restrict the flow of water and contaminants. Where the Marengo aquitard occurs above the St. Charles aquifer, the long-term well yields within the aquifer may be reduced because of the restricted recharge. However, the presence of the overlying aquitard provides the underlying aquifer with some protection from surface contamination. Relatively small bodies of sand and gravel have occasionally been found in the Marengo aquitard (fig. 7a), but these supply only small amounts of groundwater (Graese et al. 1988).

Kaneville aquifer member, Elburn aquiformation Underlying most of central and south-central Kane County, is the Elburn aquiformation, primarily an aquitard (chiefly diamicton, but also lacustrine deposits). It also contains related bodies of sand and gravel outwash that can be considered aquifers. In Geneva-Batavia Township, the Elburn aquiformation is composed of the Malden and Yorkville Till Members of the Wedron Formation. The Kaneville aquifer member of the Elburn aquiformation represents the ice-contact and outwash sand and gravel sequences of these units (fig. 6).

The Kaneville aquifer member is as much as 50 feet thick in the township and occurs above the Marengo aquitard west of Geneva (fig. 7a). Farther north the Marengo aquitard thins and the Kaneville aquifer member occurs directly over the St. Charles aquifer, but this situation is not known to occur within Geneva-Batavia Township. The top of the aquifer occurs at depths of 10 feet or less along the western edge of the St. Charles bedrock valley. Groundwater protection is important in this area, as the aquifer may be susceptible to contamination from surface sources. An example of the occurrence of the Kaneville aquifer member in the eastern portion of the study area is shown in figure 8.

Pingree Grove aquiformation Composed of stratified sands, silt, clay, marl, and peat, this unit underlies many present lakes, rivers, and streams. As it is not considered an aquifer in this area, it was not included in this investigation. The Pingree Grove aquiformation is composed of

the Equality Formation, Grayslake Peat, and Cahokia Alluvium (Curry and Seaber 1990). It is associated with wetland resources and is found at locations such as Mooseheart Lake, Peck Lake, and Nelson Lake in western Geneva-Batavia Township.

Preliminary Results of Test Drilling

Final results of test drilling will be reported by the Illinois State Water Survey. Results of one test in Geneva-Batavia Township (Section 5) have been reported by Gilkeson et al. (1987). The test well penetrated the Kaneville aquifer member and the Marengo aquitard before reaching the St. Charles aquifer within the St. Charles bedrock valley. The test well was pumped for 72 hours, with an average discharge of 1,513 gpm. The transmissivity of the aquifer at the test well was calculated to average 262,300 gal/day/ft (3.77 cm^2/sec) with a hydraulic conductivity of 2,800 gal/day/ft^2 (1.32×10^{-1} cm/sec) and storage coefficient of 3.4×10^{-4} (Gilkeson et al. 1987).

SUMMARY

Because of declining water levels and high concentrations of radium and chloride in the Basal and Midwest Bedrock Aquigroups, the cities of Geneva and Batavia are seeking alternative sources of water for public supply. The Illinois State Geological Survey has mapped the shallow groundwater aquifers of Geneva-Batavia Township as part of a comprehensive study of the shallow groundwater resources in the region. A combination of existing records, surficial geophysical surveys, and test drilling was used in the aquifer mapping phase of this study.

A second phase of this study involves aquifer pump testing to determine hydraulic properties, spacing of wells for optimal aquifer development, potential aquifer yield, and groundwater chemistry. This phase of the investigation will be reported by the Illinois State Water Survey.

Results of the geologic mapping of shallow groundwater aquifers in Geneva-Batavia Township are as follows:

- The St. Charles aquifer occurs in the St. Charles bedrock valley west of Geneva and Batavia. West of Geneva, the aquifer is more than 100 feet thick and constitutes a significant water resource. The St. Charles aquifer overlies the Upper Bedrock Aquisystem and underlies the Marengo aquitard.

- In the western part of the study area, the Kaneville aquifer member of the Elburn aquiformation occurs over the St. Charles bedrock valley. Generally, it is separated from the St. Charles aquifer by the Marengo aquitard. The Kaneville aquifer appears to have limited potential as a new source of municipal and industrial water. The aquifer may also be subject to contamination by surface sources.

ACKNOWLEDGMENTS

This study would not have been possible without the support of Ted A. Bergeson, Director of Community Affairs for the City of Batavia, and Thomas Talsma, Director of Public Works for the City of Geneva. Richard N. Young of the Kane County Environmental Department also supported the regional and local groundwater investigations in Kane County.

Many of the Illinois State Geological Survey staff contributed to the project. Douglas Laymon, Douglas Cantwell, Joseph McGinnis, Walter Morse, Philip Orozco, Steven Padovani, and Charles Tindell assisted in the field work. George Lin and Robert McGinnis processed much of the seismic field data; Paul Heigold and Vickie Poole lent their geophysical expertise toward interpretation of the data. Craig Gendron, John Skinner, Faith Stanke, and Charles Tindell assisted with organization of the extensive database developed as part of the study. Brandon Curry and Ardith Hansel provided advice on the glacial geology of the area.

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